NEW STORAGE SYSTEMS AND THEIR IMPLICATIONS

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EXHIBITS

I INTRODUCTION

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- This report's focus is on the meaning and impact of mass storage developments for the data processing practitioner.

- INPUT believes that the impact of these new developments, especially videodisk storage, has not been adequately analyzed and assessed. They will significantly impact virtually all areas of data processing.

- Besides the effects on the uses of storage media themselves, INPUT sees potential effects in most general areas of information systems:

  - System design.

  - Location of computing power.

  - Data processing economics.

  - Security.

  - Information system departmental organization.

  - Distributed data processing.

  - The "office of the future."

- Together, these impacts represent a potential for a discontinuity as great as that caused by the introduction of the System 360 in the mid-1960s.

II MASS STORAGE TECHNOLOGY

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A. CURRENT STATUS

- Mass storage has, to date, meant magnetic tape or magnetic disks.

  - Tape is being increasingly displaced by disk for daily operations, as the cost per bit stored on disk is reduced.

  - Tape is still used extensively for archival storage and backup.

    - Its utility in production environments is limited by its inherent serial nature.

  - Improvements have focused on higher densities and, recently, "streaming" drives which do not have to start and stop and can, therefore, handle large files faster.

    - These advances serve to confirm the archival and backup function.

  - There have been recurring attempts, from the data cell to the 3850, to unite the random access characteristics of disks with the large capacity and low cost of tape.

. Even the 3850 and similar devices have had low acceptance - a combination of high device costs and retrieval times of several seconds.

- Disk drives have been steadily improved over a 20-year period, starting with the 2311 and culminating in the 3380.

  - Exhibit II-1 shows the steady improvements in storage capacity and cost per bit over the last 10 years.

- The progress reflects a continual improvement in technology.

  - Higher storage density.

  - Sealed units to control the operating environment.

B. GENERAL OUTLOOK

- Tapes: Tape technology could improve further (e.g., higher densities) but manufacturers do not see a large enough market to warrant the investment, especially given the upcoming competition from videodisks.

  - Efforts will be focused on lower cost units with good performance characteristics for microsystems.

- Disks: Current magnetic disk technology appears to be reaching the point of diminishing returns, as illustrated by the production problems of the 3380.

  - Some improvement may be possible by changing the orientation of bits stored, from lying down to standing on end, a process that is currently being researched.

EXHIBIT II-1

PRICE HISTORY OF IBM 33XX DISK DRIVES

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3330-1 200 MB (6/70) $ 51,940 $260/MB			(10/73) $52,900 $265/MB		(7/75) $47,610 $238/MB		(4/77) $40,470 $202/MB		(5/79) $32,380 $162/MB	
			3330-11 400 MB (7/73) $74,000 $185/MB (10/73) $75,400 $189/MB		(7/75) $67,860 $170/MB		(4/77) $57,610 $144/MB		(5/79) $46,090 $115/MB	
					3350-B2 635 MB (7/75) $49,500 $78/MB			(10/78) $39,600 $62/MB	(5/79) $31,680 $50/MB	
									3370-B1 571 MB (2/79) $23,400 $41/MB	(12/80) $27,070 $47/MB
										3380-A4 2520MB (12/80) $97,650 $391MB

- However, this is several years away from commercial introduction.

- At most, such improvements will extend magnetic disk storage performance one more point along its historic price/performance line.

- Bubble and Electronic Memory: These will have some data storage applications in specialized areas, such as the TI 990 with a bubble storage module for increased ruggedness.

  - However, bubble memory has been the wave of the future that has never quite got off the ground because of unattractive cost/performance.

  - The recent withdrawal of National Semiconductor from the ranks of bubble memory manufacturers leaves only INTEL and the Japanese as suppliers and makes it unlikely that there will be much future effort devoted to cost reduction.

- Videodisk: Videodisk storage technology offers by far the most widespread future opportunities.

  - It is the key component in image processing systems.

  - Several other applications of videodisk technology have been publicly announced:

    - A patent data base search and retrieval system.

- An automated procedural manual for the Navy Department.

- There are also indications that several hardware manufacturers may be announcing videodisk-based storage devices in the future, including IBM's Discovision joint venture with MCA.

- INPUT sees videodisk storage technology as just entering its "take off" stage. Most of the other storage modes are entering maturity or even declining, as shown in Exhibit II-2.

C. VIDEODISK OUTLOOK

- INPUT sees a revolutionary effect developing from videodisk storage technology.

  - Other storage technology changes, as in magnetic disks, have been evolutionary; they have not (and will not) present significant risks or opportunities to data processing installations.

- The most obvious revolutionary impact of videodisk technology will be the extreme compression of data possible.

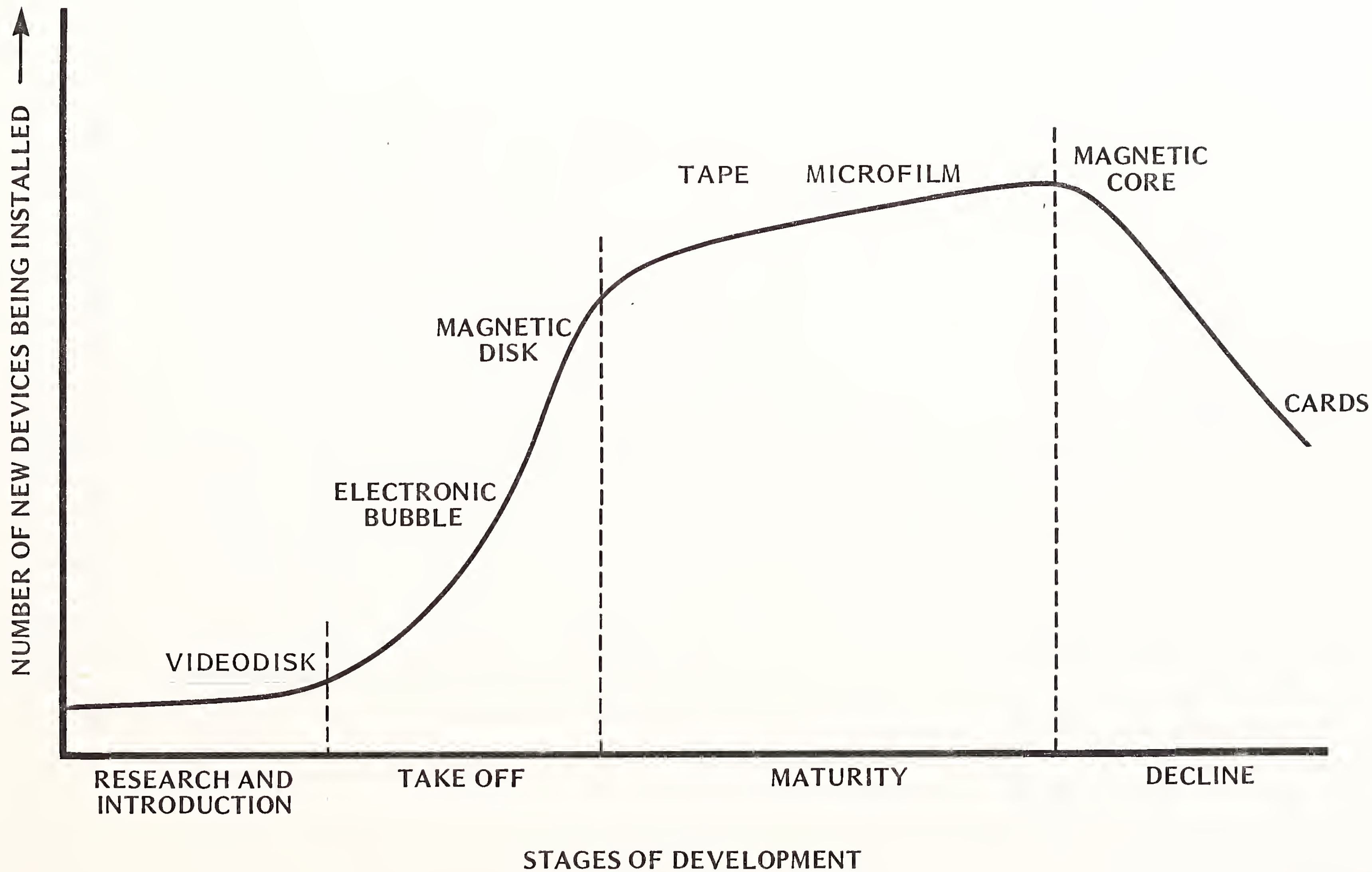
  - A single videodisk could hold 25 tape reels of 6,250 bits/inch capacity; 10 disks could be on a video pack.

- Equally important, the cost per bit of storage would fall by at least a factor of 90%.

  - This is in dramatic contrast to the historic mass storage improvement by a factor of 20% to 30%.

EXHIBIT II-2

RELATIVE DEVELOPMENT LIFE CYCLE CHARACTERISTICS OF STORAGE MEDIA



- While videodisks have the same random access attributes as magnetic disks, they currently have a significant difference that would be a drawback in many situations.

  - Data written onto the videodisk is permanent; disks cannot be written on more than once, nor can a particular piece of data be modified.

- This characteristic can nevertheless support a limited amount of updating in several ways:

  - Previously written data can be disabled with new data written in adjacent areas saved for the purpose (or at the end of the file). This approach is reminiscent of early disk access methods.

  - Another approach is to keep file indexes on magnetic media with records addressed via algorithms. The index would keep track of active and inactive records and their location.

  - Either approach would become inefficient after a certain number of additions or rewrites; the effects of volatility would depend on the particular application.

- Research is being conducted to enable videodisks to be rewritable in the same ways as magnetic media. Until this research is successful, systems planning will have to assume that the "read only" videodisks will be the basic system building blocks.

III THE IMPACT OF NEW STORAGE SYSTEMS

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A. INTRODUCTION

- Videodisk storage promises a discontinuity in both performance and price.
  - Such discontinuities are the hardest to plan for as well as the most necessary to plan for.
- The impact of videodisk storage systems will be on two levels.
  - The first level will be on applications and data processing itself. Areas to be affected include:
    - Archival storage.
    - Image processing.
    - Decision support systems data storage.
    - Relational data bases.
    - Distributed data processing.
    - Micrographics.

- Information data base products.

- The second-level effects will be broader and will flow, directly and indirectly, from the first level. These include impacts on the following:

  - System design.

  - Data processing economics.

  - Location of computing power.

  - Information systems department responsibilities.

  - Data security.

  - Office of the future.

- Each of these impacts is discussed in more detail in the sections that follow.

B. APPLICATION AND PROCESSING IMPACTS

1. ARCHIVAL STORAGE

- The most obvious use for videodisk storage, especially initially, will be for archival copies.

  - This use will be pushed by vendors, since it could be implemented immediately.

  - In large installations, the savings in time and money would be obvious, big, and easy to document.

- The read-only mode videodisk would be more advantageous in this application, since it would be much more difficult than at present for incorrect data to be introduced into the file.

  - Videodisks should also be more stable physically than tape and, consequently, a better storage medium. Lifetimes of up to 25 years without rewriting are expected, compared to six months for magnetic tape.

2. IMAGE PROCESSING

- Image processing is a "natural" for videodisk storage.

- An INPUT Vendor Watch Report, <u>Image Processing Systems - Concepts and Status</u>, focused on the area.

  - The "VIPS-2000" System is a commercially offered system that was described at some length.

- Recently, Pergamon International announced an on-line patent search system that will use videodisk storage for graphics data, with first deliveries in July 1981.

    - Microfilm was originally planned for this information.

    - This is to be the first of a number of on-line/graphics data bases planned by the company.

- The ability to mix graphic information (pictures and/or text) on the same storage media with digital data will be very convenient in such applications as:

  - Scientific and engineering field and experimental data.

  - Medical records.

- Engineering drawings.

- Catalogs.

- Cartography.

- Information could initially be entered and stored as an analog (picture) image and later, if necessary, converted to digitally processible data. For example:

  - Externally entered text could be digitized later if modifications were needed later.

3. DECISION SUPPORT SYSTEM DATA STORAGE

- An increasing opportunity area for many companies is to apply decision support system technology to solve the company's problems.

- One of the more attractive areas of opportunity for applying decision support systems is on detailed company operating data.

  - However, this application can be very expensive in terms of computer resources if, for example, an IMS data base must be accessed in order to perform operations research types of analyses.

- Some companies are considering dedicating a CPU to these types of exercises (e.g., a 4300 or a superseded 158).

  - This is done as much to isolate the production CPU from the surges of decision support system activity as to provide a higher level of service to users.

- However, there is no way to provide similarly isolated data files, given present storage costs and technology.

    . File extracts and summaries are useful, but often do not provide the material needed for the most powerful and productive analysis.

- Providing a videodisk copy of the needed master file could be an ideal solution.

    - The decision support systems analysts rarely, if ever, require a completely up-to-date version of the data in question. In fact, constantly changing data is often inappropriate for use in such research.

    - The greatly increased processing time usually required will be little or no burden, since decision support analyses of this type rarely are real-time oriented.

4. RELATIONAL DATA BASES

- Two facts emerge from the plethora of technical and speculative writings about relational data bases.

    - They are, in concept, large two-dimensional matrices where one very large array of data elements is mapped against another very large array. A tabulation of the intersections permits many relationships to be mapped.

    - In their purest, most powerful form they will consume an inordinate amount of mass storage.

- Consequently, videodisk files would be very powerful implementors for relational data bases.

- Obviously, videodisks in the present "read-only" mode would be feasible only for fairly static data bases.

  . It is not clear how limiting a factor this would be. To the extent that relational data bases are used in research and analysis (e.g., decision support systems), then videodisk technology would be well suited to support relational data bases.

5. DISTRIBUTED DATA PROCESSING

- The positioning of CPU power is no longer a serious impediment to distributed data processing (DDP) as a result of the significant price/performance advances in recent years.

- Data storage is now the chief problem in designing and implementing DDP systems. These issues include:

  - How much data will reside at distributed locations?

  - How much will the data at a particular location overlap and duplicate that at other locations?

  - If necessary data does not reside at a particular location, how do local programs which need this data coordinate their processing with programs at other locations?

  - These issues apply whether various locations have equal status or if there are one or more hosts which have secondary nodes attached to them.

- One of the main issues in distributed system design is how to reduce both data duplication and communications costs.

- Often an uneasy compromise results, with enough data distributed to do some processing locally; but the remaining processing must be performed periodically at a host site.

  . This additional processing might be performed on a real-time basis or, quite often, on a daily remote job entry basis with overnight turnaround.

- This concept gives the appearance of DDP since an impressive number of CPUs (e.g., 4300s) are sprinkled about. However, from the central system's viewpoint, they are only performing some limited pre-edits. Control and decision-making are retained centrally.

• These compromises often occur because of the need to use large master files in processing. It is usually not worth the time and expense of attempting to maintain these files at multiple locations. In addition, there are serious technical problems which now constrain DDP development:

- The more separate versions there are of the same file, the greater the danger of the files getting out of synch.

- Even more of a problem is the limited line speeds commonly available for data transmission.

  . Even a 4,800 bit per second (bps) line would take many hours to transmit a single reel of tape.

• Disk-to-disk transmission of data is even less developed (in part reflecting the fact that designers don't even consider this sort of transmission very often).

• DDP data storage concepts are now fuzzy. DDP design involves a series of debilitating compromises.

- Not surprisingly, DDP involving distributed data storage as well as processing is more talked about than acted upon.

- DDP in a videodisk environment will allow large data files to reside locally and be transported physically or electronically, but only once per generation.

- A videodisk environment will give DDP some intriguing design options not now available.

    - Obviously, very large data files could reside at many local sites. These files could be, in principle, the company's master file.

    - Where changes were made on a controlled basis (e.g., catalogs, parts lists, etc.), these files could be replaced periodically by courier.

    - Master files that are updated daily could have update transactions sent electronically.

        - Another possibility would be to use one of the emerging value-added satellite-based telecommunications services to transmit large portions of the file daily and recreate the entire file. This would be very suitable to the "read-only" characteristics of videodisks.

6. MICROGRAPHICS

- It is difficult to see a role left for micrographics (microfilm, microfiche) in a videodisk environment.

- Micrographics will not enjoy a cost edge, even at the beginning.

    - Videodisks are likely to pull further ahead, given the historic cost decreases associated with electronics.

- Organizations with large numbers of CRTs already in place for data processing applications will need no other output hardware.

- Micrographic viewing access is in practice usually limited to places where a microform copy exists.

  - Videodisk information will be accessible wherever a CRT can link into the same network as the videodisk.

- Videodisks will solve the two biggest problems of micrographics:

  - Indexing/accessing.

  - Making full-size copies.

- Micrographics are easy to use and cheap only where indexing and hard-copy issues are poorly addressed.

  - Expensive hardware is required to produce results that are still only partially satisfactory.

- On the other hand, videodisk data can be indexed almost as easily as magnetic disk data (even in the mode that would not permit rewriting).

  - Accessing will be measured in milliseconds for most applications and, at most, only a few seconds where a videodisk mount is involved.

- Making copies of videodisk material will be limited only by the availability of standard output devices.

7. INFORMATION DATA BASE PRODUCTS

- Information data base products represent one of the growth areas of the 1980s. These include the following:

- Stock quotations.

- Bibliographic indexes.

- Product descriptions (e.g., medical apparatus).

- News services.

• These are digitized and accessed via an on-line network, typically from a remote computer services vendor.

• However, these data bases have differing storage characteristics in two critical respects:

  - Volatility.

  - Graphics orientation.

• Exhibit III-1 illustrates the broad range of volatility of the data in an information data base.

  - On one extreme are stock price quotation services where it would be common for 99% of the data to change from one day to the next.

  - On the other extreme are data bases of facts about the physical world which will change very slowly.

  - There is a large middle category of information areas which are constantly changing, but at a relatively slow rate.

  - Absolutely up-to-date information is rarely critical for most users.

• Contrasted with the rate of volatility of the data in the information data base is the amount of image content represented by the data.

EXHIBIT III-1

INFORMATION DATA BASE VOLATILITY CHARACTERISTICS VERSUS IMAGE CONTENT

IMAGE CONTENT	DATA VOLATILITY		
	LOW	MEDIUM	HIGH
LOW	• GENERAL INTEREST BOOKS	• PERODICAL INDICES • LEGAL CITATIONS	• STOCK QUOTATIONS
MIXED	• GEOLOGICAL DATA • ENGINEERING AND SCIENTIFIC DATA	• PRODUCT DESCRIPTIONS • ECONOMIC TIME SERIES	• NEWS SERVICES
HIGH	• CARTOGRAPHIC DATA • ELECTRONIC PUBLISHING	• PATENT DESCRIPTIONS	

- Here stock quotations rank low, with cartographic information and patent descriptions placing very high on the image content scale.

- It is quite likely that many information data base applications will migrate from an RCS mode of delivery to an in-house videodisk-based mode. This will be dependent on several factors:

  - The amount of information used and the number of users.

  - The higher the image content and the importance of accessing images, the more attractive in-house videodisk systems will become.

  - Hybrid services will make the tradeoffs less stark.

    - Historic image data can be stored on-site and new data can be obtained from the RCS vendor.

C. FUNCTIONAL AND MANAGEMENT IMPACTS

1. SYSTEM DESIGN

- One of the most disquieting things in data processing is the generally sad state of systems analysis and design.

  - Technology continues to make constant, creative leaps while anchored to an engineering discipline.

- There have been some attempts to introduce engineering concepts into software analysis and design; however, they have had little acceptance.

- Even software construction techniques, which in principle may be much more amenable to a systematic approach than design, have not progressed beyond a certain rudimentary level of automation.

- Systems are still being designed today that have hardly overcome tab system characteristics.

  - Multiples of 80-column records are faithfully carried through generations of modifications.

  - Disks are treated as tapes.

  - Data base management systems are used mainly as access methods.

- As long as analysis and design are treated as arts, there will be little progress in the innovative application of new technology to business problems.

  - There are only a limited number of artists in the general population.

  - This proportion is further reduced by the widespread notion that one must be a coder before becoming an analyst/designer.

- Consequently, it takes the systems analyst "profession" a very long time to absorb the meaning of technological developments for systems design.

  - While, in theory, system specifications should flow from an analysis of requirements, in reality people often pose problems in such a way that the solution is already on the shelf.

- This phenomenon strongly inhibits the design of systems which will take advantage of the unique properties of videodisk storage.

  - Initially, systems designers will treat videodisk storage as an archival medium; i.e., they will ignore it.

- Designers will be encouraged to do so by hardware manufacturers who will tend initially to market videodisk storage as an archival and backup device.

- Since the early videodisk offerings will be the read-only type, this will place special demands on system designers:

  - The amount of data volatility will be crucial in designing cost-effective (or even feasible) videodisk-centered systems.

  - The challenge will be to segment systems data needs and functions in such a way that the proper blend of magnetic disks and read-only videodisks is used.

- Hopefully, the later emergence of fully writable videodisks will remove these problems and ease the associated design and analysis tasks.

2. DATA PROCESSING ECONOMICS

- The impact of cheap videodisk technology on data processing economics is not as clearcut as may at first be assumed.

  - If an organization did nothing but replace current storage with video-disk storage, there would be obvious hardware savings.

  - However, it is almost certain that the new storage technology will stimulate further use of computing.

- More files will be stored at more locations.

  - Communications costs will increase.

  - More processing nodes will be used to manipulate these files.

- The new technology will span new types of applications. (Section B of this chapter analyzed the types of applications that could be involved.)

    - Many of these applications could be very processing-intensive.

- The net result is that the decreasing unit costs in storage may not result in a drop in the absolute amounts spent on storage.

    - This has been true historically for both CPU and magnetic storage costs.

3. LOCATION OF COMPUTER POWER

- If videodisk storage technology produces the drop in storage costs that has already occurred in CPU costs, then the classic corporate data center will be much harder to justify on the basis of economies of scale in hardware.

- Changes will still occur slowly because of the following:

    - Psychological and organizational lag.

    - Computer operations and control will have to be simplified (without losing effectiveness) so operations staff requirements can also be appreciably reduced.

    - Neither of these challenges is trivial.

4. INFORMATION SYSTEMS DEPARTMENT RESPONSIBILITIES

- A subtle effect of videodisks is that they will call into question the standard centralized DP organization that typically exists today.

    - Most successful information systems activities today are essentially highly structured organizationally; i.e., there are at minimum:

        - Central planning.
        - Central accounting.
        - A central corporate data base.
    - Planning and accounting are centralized to make the best use of organization-wide data and hardware resources.
    - A central corporate data base exists because it does not make economic sense to store a complete set of data at redundant points.

- What if the additional cost of storing and processing a complete set of corporate data at many different locations was trivial?
    - Granted, there would be some additional costs for keeping the data in synch and for data transmission.
    - But this might be more than balanced by the value of having more information available to more people.
    - Equally important, the data may be more up to date and correct, since more people would be examining it on a regular basis.

- There would still be a need for a central technical advisory staff.
    - But would there be any role left for a central unit in charge of computer-based management information systems?
    - There would be more need than ever before for central staff to <u>interpret</u> corporate information such as the following:
        - Financial information.

- Operating information.

- Marketing information.

- Other functional, business-related information.

- The solely technically based "computer czar" that exists today would be poorly positioned to assume any of these functions.

5. DATA SECURITY

- Videodisk technology is a two-edged sword as far as security is concerned.

  - On the one hand, security will be significantly enhanced relative to inaccuracy and catastrophic destruction of data.

    - Read-only videodisks will, by their very nature, create regular generational copies of data bases where the videodisk is the primary means of storage. These copies will be, by definition, permanent and much more secure than magnetic disk or tape files.

    - Where magnetic disks are the primary storage medium, videodisks will be the ideal backup since they can mimic the random access organization. Thus, unlike magnetic tape, particular logical or physical data base segments can be easily retrieved and restored when needed.

  - On the other hand, videodisks by their compact nature (and profusion) will represent a serious security problem relative to theft or unauthorized use of data.

- Current computer security breaches rarely involve large amounts of data.

- A typical problem is that data input is falsified.

- Sometimes, program logic is tampered with.

- However, stealing large amounts of data means getting physical access to a file and copying it (or trying to physically remove it).

- In either case, this means circumventing the physical and procedural controls of the computer operations area - which generally has the most elaborate and effective controls in the DP department.

• However, if what now requires 10 or 20 tapes to store will soon fit on something not much larger than a single phonograph record, then the security picture changes.

  - This risk is especially serious in the case of the read-only versions which will be discarded on a regular basis.

  - A corporation's detailed financial transactions, or the entire data base of an information supplier, would be worth considerable money to a disgruntled employee.

• Three types of control will be necessary.

  - A comprehensive tracking system could account for each videodisk's whereabouts.

    . However, this problem reaches ridiculous proportions if there are tens of thousands of disks circulating between hundreds of locations.

  - Videodisks could be made difficult or impossible to copy (as is done now with entertainment videotapes).

- However, this would go directly counter to one of videodisk's main functions - backup of magnetic files.

- More importantly, a sophisticated penetrator could without doubt find ways to read the file.

- The only safe method is encryption.

  - Sensitive data would be encrypted using a carefully controlled electronic key.

  - Use of the key for subsequent processing (either at the point or creation or at other sites) would be carefully controlled.

  - The data on the disk itself would be unintelligible and the "plaintext" could not be broken, for all intents and purposes (i.e., in less than several hundred years).

  - But the added expense of encryption could significantly negate the cost advantages of the videodisk.

6. OFFICE OF THE FUTURE

- The videodisk will enable office nodes to be self-contained, functioning entities.

  - The videodisk's ability to handle data and pictures simultaneously will allow word processing, data processing, and image processing to become integrated.

    - Most importantly, image storage can be supported.

- Quite often, only an image of material need be stored for later use. There is no need to have the material itself digitized so that it can be computer processed; index entries would be sufficient.

- Much correspondence falls into this category.

IV CONCLUSIONS.

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- If even a fraction of these mass storage changes takes place, data processing as it is now known and practiced in many organizations will no longer exist.

  - To some extent, this will only be an acceleration of current trends.

  - The very attractive economics and performance of videodisk-based technology will remove many of the existing barriers to change.

- There is little question that the bandwagon will not really start to roll until IBM gives videodisk technology its stamp of approval. The timing on such changes is uncertain:

  - On the one hand, IBM has been a technical leader in storage devices.

    - It would be unwilling to give up its strong position in videodisk technology.

  - On the other hand, IBM will have to assess the market impact of what it does very carefully.

    - The industry (and IBM itself) have only now recovered from the shock caused by the price/performace of the 4300 (which was, after all, not a technological discontinuity).

- To unleash a new technology that, in its fully writable form, would obsolete all current storage, is not a step that IBM will take lightly, considering its enormous installed data storage base.

- To add insult to injury, the new devices could represent a fall of at least 90% in cost/bit rather than the 20-30% decline between models that has been the IBM rule.

- However, if IBM stands back as it did in minicomputers, the results could be even worse in the longer run.

  - Obviously, for IBM:

    - Customers will not know which of the alternatives to buy, or whether to buy at all.

    - Without an initial de facto standard, a number of incompatible offerings may emerge, as has occurred in consumer videodisks; not all would survive.

- Even after initial acceptance and use of videodisks, their revolutionary impact will usually not be obvious.

  - Initially, they will be used experimentally or within existing systems.

  - Even in new systems, they will often only be used as cheaper disks. (Just as, analogously, disks were for quite some time used with design concepts derived from tape systems.)

  - There will first be a great deal of older equipment to dispose of in an orderly fashion (i.e., wait until it has been depreciated).

- Human inertia and unwillingness or the inability to change should not be discounted either.

    - The use of punchcards, for example, continued to increase well into the 1970s in spite of the existence and considerable use of much more cost-effective alternatives.

    - 360s, 1401s, and even 401s continue to be usefully employed in many organizations. (If emulation and one-for-one conversions are counted, the 1401 technological approach may still account for a substantial amount of processing in many organizations.)

- However, organizations which can find objective business reasons for using the new mass storage technology can provide themselves an edge in terms of some or all of the following:

    - Cost reduction.

    - Increased responsiveness to user needs.

    - Increased business growth.

    - More secure and reliable systems.

- From an operational standpoint, the real questions become:

    - Should I order a dozen 3380s?

    - Should I lease them?

- Unquestionably, if there are immediate needs for more storage now and there is quick (one- to two-year) payback, such money is well spent.

- If the investment is in reality marginal, then reflecting on its likely obsolescence may help to delay an expenditure that probably should not be made anyway.